

S/N 09/945,535

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Kie Y. Ahn et al.

Examiner: Colleen Rodgers

Serial No.: 09/945,535

Group Art Unit: 2813

Filed: August 30, 2001

Docket: 1303.026US1

Title: HIGHLY RELIABLE AMORPHOUS HIGH-K GATE OXIDE ZrO₂

REPLY BRIEF UNDER 37 C.F.R. 41.41

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Commissioner for Patents

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This Reply Brief is filed in response to the Examiner's Answer (hereinafter "Answer"), mailed on December 12, 2008, and supplements the Appeal Brief previously filed by the Appellant on September 22, 2008. If necessary, please charge any additional fees or credit overpayments to Deposit Account No. 19-0743.

REPLY

REMARKS

The Examiner's Answer Brief ("Examiner's Answer"), dated 12 December 2008, includes similar grounds for rejection as the last Final Office Action. Appellant respectfully maintains that the Appeal Brief, which is hereby incorporated by reference and reasserted in response, in view of this Reply Brief overcomes the original grounds of rejections.

Comments by Appellant Relating to the Examiner's Answer

The Appellant has reviewed the Examiner's Answer, and believes the statements in the original Appeal Brief remain substantially compelling. In responding to the Examiner's Answer, the Appellant wishes to further clarify certain points of distinction between the pending claims and the cited references in response to the presented Examiner comments. The corresponding pages of the Examiner's Answer will be used to reference each of these points.

In addition, any lack of reference in this Reply Brief to a particular argument in the pending Appeal Brief is not to be construed as an admission that the Appellant agrees with any of the statements in the Examiner's Answer. Appellant asks that the statements made in Appellant's pending Appeal Brief be considered in full, in addition to the statements included with this Reply Brief.

Discussion of the rejection of claims 1, 2, 6, and 7 under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589; hereafter Ma) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923; hereafter Yano).

Claim 1

Regarding the Examiner's Answer with respect to the rejection of claim 1, the Examiner's response fails to demonstrate that the cited references taken individually or in combination disclose or suggest all the elements of claim 1 interrelated as recited in claim 1, taken as a whole. For example, at page 8 of the Examiner's Answer under Response to Argument, the Examiner states that

... The Examiner, as before, concedes that **Ma et al** teach a preferable metal film contains the trivalent metal dopant. However, **Ma et al** clearly contemplate a scenario where the metal film is undoped; the Examiner points to **Ma et al**, column 5, lines 65-66, wherein “[t]he percentage of Al, or other trivalent metal, in film 56 is in the range of approximately 0 to 50%.” Regardless of the teaching of a preference for a heavily doped metal layer, **Ma et al** have provided an explicit teaching of a substantially pure single metal layer.

Claim 1, in part, recites “evaporation depositing a substantially amorphous and 0.99999 pure single element metal layer.” Ma recites “percentage of Al, or other trivalent metal, in film 56 is in the range of approximately 0 to 50%.” The “percentage of Al, or other trivalent metal, in film 56” cannot be less than zero. The lower bound in the cited section of Ma et al is “approximately 0.” “Approximately 0” is not zero and hence Ma does not recite a 100% pure single element. To one skilled in the art, the use of the term “approximately 0” would depend on the entire disclosed range. Since the upper range is 50% and not 50.0%, it would be reasonable to take the metal layer of Ma as having a metal in addition to the primary metal with a lower end percentage to be 0.1% (0.999 pure). The subsequent discussion of Ma et al regarding preferable amounts of the additional metal further demonstrates that Ma does not contemplate using a pure (100 %) single metal layer or “a 0.99999 pure single element metal layer” in his method.

On page 9 of the Examiner’s Answer, the Examiner noted that “[o]n page 12 of the Appeal Brief, Appellants allege that ‘Park teaches away from the use of evaporation.’” This statement was made in response to the statement regarding Park in Final Office Action: “Park teaches . . . by either sputtering or electron beam deposition . . . It would have obvious to one of ordinary skill in the art at the time of invention to use e-beam evaporation deposition because it has been held that simple substitution of one known method for another to obtain predictable results is obvious. See *KSR International Co. v. Teleflex Inc.*, 82 USPZ2d 1385 (2007).” As noted on page 12 of the Appeal Brief, Appellant’s specification discussed adverse roughness properties from sputtering. With the Examiner’s apparent proposition, in the above quote, that electron beam deposition is equivalent to sputtering, one skilled in the art would be directed away from using e-beam evaporation to form a metal oxide layer having roughness as recited in

claim 1.

Appellant notes that the Examiner is correct in that Park recites evaporation of zirconium by an electron beam at column 4, lines 25-27. However, as with Ma et al, Park does not disclose or suggest using a pure single metal layer or “a 0.99999 pure single element metal layer” in his method. Park at column 4, lines 25-27 recites “[f]or an electron beam deposition process, highly pure zirconium of 99.0% or higher is evaporated in a high vacuum of 10^{-8} - 10^{-11} torr by an electron beam.” Appellant submits that “zirconium of 99.0% or higher” does not disclose or suggest using a pure (100%) single metal layer or “a 0.99999 pure single element metal layer,” but that one skilled in the art would take “99.0% or higher” to have an upper range of 99.9% corresponding to that of Ma.

At page 9 of the Examiner’s Answer, the Examiner states “[w]hile the Examiner concedes that evaporation deposition and sputtering are distinct processes with distinct characteristics, both are notoriously well known in the art for deposition of a single-metal layer. One of ordinary skill in the art would be motivated to employ whatever process suited the characteristics desired in the deposited layer.” However, as demonstrated above, neither Park nor Ma et al disclose or suggest “evaporation depositing a substantially amorphous and 0.99999 pure single element metal layer directly contacting a single crystal semiconductor portion of the body region using electron beam evaporation,” as recited in claim 1 of the instant application.

On page 9, with respect to the citation of Yano, the Examiner states “**Yano et al** teach evaporation deposition of a single metal layer . . . and oxidizing the metal . . . and that the surface roughness is up to 0.6 nm across the surface.” With respect to the “amorphous” features of claim 1, the Examiner further states “while it is true that **Yano et al** teach a preferred crystalline metal rather than an amorphous metal, **Yano et al** also teach that it is known to make the metal amorphous,” without providing a citation to a section in Yano. In an electronic search of Yano, Appellant found discussion of amorphous silicon and amorphous silicon oxide, but not a discussion of an amorphous “metal being chosen from the group IVB elements of the periodic table” or corresponding amorphous metal oxide as recited in claim 1. Though Appellant does not necessarily agree, one may argue that Yano’s discussion of forming epitaxial (crystalline) zirconium oxide may imply that if one varies from Yano’s method that an amorphous zirconium

and/or corresponding zirconium oxide may form. However, completing the argument regarding deviation from Yano's method to include amorphous features, one skilled in the art would be lead to interpret such deviation to include the surface roughness of the formed amorphous zirconium oxide deviating from that of the epitaxial formed zirconium oxide. Thus, the amorphous layer of Yano proposed by the Examiner would have a surface roughness significantly greater than 0.6 nm across the surface. In contrast, claim 1 recites "oxidizing the metal layer to form a metal oxide layer directly contacting the body region, wherein the metal oxide layer is amorphous and has a smooth surface with a surface roughness variation of 0.6 nm." Thus, Yano appears void of a disclosure or a suggestion of a metal oxide layer that is amorphous and has a smooth surface with a surface roughness variation of 0.6 nm, where the metal is chosen from the group IVB elements of the periodic table. Such feature is also missing in the combination of Ma and Park.

With respect to the "amorphous" feature of claim 1, the Examiner states "the instant specification teaches that the metal layer may be either amorphous or crystalline, with no criticality taught between the two types." Appellant notes that a patent application may disclose numerous inventive embodiments in its specification and that an application may include a generic claim to all embodiments or claims that include a set of the embodiments. The claims of the instant application, as recited in claim 1, include the limitations to "substantially amorphous and 0.99999 pure single element metal layer" and "the metal oxide layer is amorphous." The specification does not state or imply that amorphous and crystalline are the same or that one can be substituted for the other and provide the same result. To the contrary, the specification on page 7, lines 15-19 notes that the amorphous form leads to reduced leakage current through a final gate oxide, for example. This demonstrates that the claimed amorphous features are different from crystalline features. Thus, the Examiner's statement that "the metal layer may be either amorphous or crystalline" improperly interprets amorphous to include crystalline. Such an interpretation is not a reasonable interpretation and is not consistent with the Appellant's specification.

Appellant notes that crystalline is a structural feature that is significantly different from an amorphous structure. As such, the difference between crystalline structure and amorphous

structure is not one of a degree, a dimension, or a variable. Therefore, the instant application need not recite a criticality as proffered by the Examiner. However, the instant application, as mentioned above, does point out a significant feature enhancement for the amorphous features of claim 1 that more than satisfies the Examiner's need for criticality in the amorphous limitation.

From the discussion above, it is clear that Examiner's response fails to demonstrate that Ma, Park, and Yano taken individually or in combination disclose or suggest all the elements of claim 1 interrelated as recited in claim 1, taken as a whole. Further, the discussions in the Office Actions of record do not provide a basis for assuming that the missing elements are obvious. Considering claim 1 as a whole and the differences between claim 1 and the cited references, Appellant submits that claim 1 is patentable over Ma et al. in view of Park and Yano et al.

Claims 2, 6, and 7

Dependent claims 2, 6, and 7 are held to be patentable at least as depending from patentable base claims as shown above, since any claim depending from a non-obvious independent claim is also non-obvious.

Appellant respectfully requests withdrawal of these rejections of claims 1, 2, 6, and 7 and allowance of these claims.

Discussion of the rejection of claims 8 and 9 under 35 U.S.C. § 103(a) as being unpatentable over Ma et al. (U.S. Patent No. 6,207,589; hereafter Ma) in view of Park (U.S. Patent No. 5,795,808) and Yano et al. (U.S. Patent No. 5,810,923; hereafter Yano) as applied to claims 1, 2, 6, and 7 above, and further in view of Moise et al. (U.S. Patent No. 6,211,035; hereafter Moise)

Claims 8 and 9

Regarding the Examiner's Answer with respect to the rejection of claims 8 and 9, the Examiner's response fails to demonstrate that the cited references taken individually or in combination disclose or suggest all the elements of each of claims 8 and 9 interrelated as recited

in each of claims 8 and 9, taken as a whole. The Examiner states on page 10, “the teachings of **Moise et al** are not intended to suggest the use of pure single metal layers, but rather to teach the inclusion of a krypton/oxygen plasma process.” On page 7, the Examiner states “**Moise et al** teach oxidizing a metal layer with inert gases such as argon and krypton [see col. 12, lines 23-24]. It would have been obvious to one of ordinary skill in the art at the time of invention to use krypton because it has been held that simple substitution of one known method for another to obtain predictable results is obvious. See *KSR International Co. v. Teleflex Inc.*, 82 USPZ2d 1385 (2007).” No further discussion or explanation is given by the Examiner. Moise at column 12, lines 20-32 recites:

This sequence of steps can also be reversed for the case of diffusion barrier etchback prior to ILD deposition.

The chemistries for the SiO₂ etch should contain a mixture of H- and F-containing gas, and an inert gas (e.g., He, Ne, Ar, Kr, Xe) can be used. The preferred chemistry for a particular reactor (AMAT P5000 RIE system) consisted of 15 sccm CF₄, 30 sccm CF₃ H and 100 sccm Ar flows to give a total process pressure of 100 mTorr.

Of course, other gases (e.g., CH₂ F₂, CH₃F, CH₄, C₂F₆, C₃F₆, C₃F₈, XeF₂, NF₃, SF₆), can be the sources of the F and/or H species. An etch chemistry which substitutes or adds compounds containing Cl, Br or I species will have similar properties.

The Examiner has not explained the reason that the Examiner believes etching (removing material) a metal relates to oxidizing a metal to form an oxide of the metal. Appellant notes that silicon is different from a metal chosen from the group IVB elements of the periodic table and that chemistries involved with etching silicon oxide do not provide a predictable result for applying the chemistries to oxidizing a metal to form an oxide of the metal, the metal being chosen from the group IVB elements of the periodic table. Thus, Appellant submits that Moise, as proffered by the Examiner, does not teach the krypton/oxygen plasma process recited in each or claims 8 and 9 that is also missing in the combination of Ma, Park, and Yano.

From the discussion above, it is clear that Examiner’s response fails to demonstrate that

Ma, Park, Yano, and Moise taken individually or in combination disclose or suggest all the elements of each of claims 8 and 9 interrelated as recited in each of claims 8 and 9, each individually taken as a whole. Further, the discussions in the Office Actions of record do not provide a basis for assuming that the missing elements are obvious. Considering claims 8 and 9, each individually taken as a whole, and the differences between claims 8 and 9 and the cited references, Appellant submits that claims 8 and 9 are patentable over Ma et al. in view of Park and Yano et al and further in view of Moise et al.

Appellant respectfully requests withdrawal of these rejections of claims 8 and 9, and allowance of these claims.

The Examiner's discussion of Moise further demonstrates that the Examiner has not considered each of the claims of the instant application individually taken as a whole. Appellant respectfully requests withdrawal of the rejections of claims 1, 2, and 6-9, and allowance of these claims.

Conclusion

The pending claims subject to this appeal are believed patentable. Appellant respectfully submits the claims are in condition for allowance and requests the Board issue an order to withdraw the rejections of claims 1, 2, and 6-9 to issue a patent with claims 1, 2, and 6-9.

If necessary, please charge any additional fees or credit overpayment to Deposit Account No. 19-0743.

Respectfully submitted,

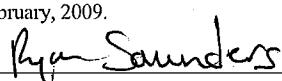
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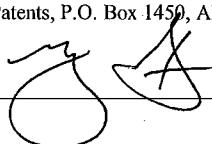
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